VARIABLE STIFFNESS ELECTROACTIVE POLYMER SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119(e) from U.S. Provisional Patent Application No. 60/293,005 filed May 22, 2001 now abandoned, which is incorporated by reference herein for all purposes; this application also claims priority under 35 U.S.C. §119(e) from U.S. Provisional Patent Application No. 60/327,846 entitled Enhanced Multifunctional Footwear and filed Oct. 5, 2001 now abandoned, which is incorporated by reference herein for all purposes.

BACKGROUND OF THE INVENTION

The present invention relates generally to electroactive polymer technology. More particularly, the present invention relates to electroactive polymer systems that provide electronically variable and electronically controlled stiffness and/or damping.

In many applications, it is desirable to electronically vary or control the stiffness within a system. Common techniques for providing stiffness include spring based designs that allow directionally specific compliance using one or more springs, or materials, of a known stiffness. When control is desired, these designs lose their simplicity and become complex quite readily, requiring specialized mechanisms and actuators to adapt performance.

Conventional systems for providing damping include fluid-based damping devices and other complex mechanical dampers. Again, variation in the damping applied by these devices, or damping control as desired for an application, adds a considerable amount of complexity and cost. In addition, conventional systems for providing stiffness and damping do not scale well to smaller sizes.

In view of the foregoing, alternative devices and systems that provide variable stiffness and damping without undue complexity or cost would be desirable.

SUMMARY OF THE INVENTION

The present invention relates to variable stiffness and damping systems that comprise one or more electroactive polymer transducers.

In one aspect, the present invention relates to a system for providing a desired stiffness using an electroactive polymer transducer. The system comprises a device including a mechanical interface capable of displacement. The device also comprises a transducer having at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface. The polymer is arranged in a manner that allows deflection of the polymer corresponding to displacement of the mechanical interface. The system also comprises control electronics in electrical communication with the at least two electrodes and designed or configured to set or change the electrical state of the transducer in order to cause a corresponding setting or change in the stiffness of the device.

In another aspect, the present invention relates to a system for providing damping using an electroactive polymer transducer. The system comprises a device including a mechanical interface capable of displacement. The device also comprises a transducer having at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface. The polymer is arranged in a manner that allows deflection of the polymer corresponding to displacement of the mechanical interface. The system also comprises control electronics in electrical communication with the at least two electrodes and designed or configured to set or change an electrical state of the transducer. The system further comprises dissipative electronics in electrical communication with the at least two electrodes and designed or configured to dump electrical energy in response to a change in the electrical state.

In yet another aspect, the present invention relates to a system for providing a desired stiffness using an electroactive polymer transducer. The system comprises a device including a mechanical interface capable of displacement. The device also comprises transducer having at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface, the polymer arranged in a manner that allows deflection of the polymer corresponding to displacement of the mechanical interface. The system also comprises open loop control electronics in electrical communication with the at least two electrodes and designed or configured to set or change the electrical state of the transducer in order to cause a corresponding setting or change in the stiffness of the device.

In still another aspect, the present invention relates to a system for providing a desired stiffness using an electroactive polymer transducer. The system comprises a device including a mechanical interface capable of displacement. The device also comprises transducer having at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface, the polymer arranged in a manner that allows deflection of the polymer corresponding to displacement of the mechanical interface. The system also comprises control electronics in electrical communication with the at least two electrodes and designed or configured to set or change the electrical state of the transducer in order to cause a corresponding setting or change in the stiffness of the device. The system further comprises a sensor configured to detect a parameter related to the desired stiffness and provide feedback to the control electronics. In many cases, the sensor measures force and/or motion, and stiffness is computed to provide control.

In another aspect, the present invention relates to a system for providing a desired stiffness using an electroactive polymer transducer. The system comprises a device including a transducer comprising at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes. The system also comprises control electronics in electrical communication with the at least two electrodes and designed or configured to set or change an electrical state that results in a desired deflection for the polymer, the desired deflection corresponding to a structural state of the device that results in the desired stiffness for the device.

In still another aspect, the present invention relates to a system for providing damping using an electroactive polymer transducer. The system comprises a device including a mechanical interface capable of displacement. The device also comprises a transducer comprising at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface. The polymer is arranged in a manner that allows deflection of the polymer corresponding to displacement of the mechanical interface. The system